

Anatomical Structure of the Rhizoma of *Zingiber Officinale* Roscoe (Zingiberaceae Family)

*Nazokat Ergashbaevna Shukurullayeva*¹, *Gulrukh Korkmasovna Rakhimova*², *Rukhsora Korkmasovna Shomurotova*³, *Dilmurodov Marufjon Elmurodovich*⁴

¹Master Institute of Pharmaceutical Education and Research,

²Associate Professor, Institute of Pharmaceutical Education and Research

³Senior Lecturer, Department of Microbiology, Virology and Immunology, Tashkent State Medical University

⁴Student of the Institute of Pharmaceutical Education and Research

*Correspondence: gulruhrahimova1970@gmail.com

Abstract: The microscopic structure of *Zingiber officinalis* L., a medicinal plant widely used in Uzbekistan, was studied and diagnostic signs were identified. The rhizome was round in cross section, and its structural structure was determined to be of a parenchymal-ligamentous type. The rhizome is covered with a number of oval-shaped rhizoderm cells. The primary cortex is formed from meristematic cells in the middle part of the growth cone and consists of exoderm, mesoderm, and endoderm layers. These identified diagnostic signs can serve to identify plant raw materials.

Introduction

Medicinal ginger - *Zingiber officinalis* L. is a perennial herbaceous plant with a thick rhizome, belonging to the family Zingiberaceae, the class of monocots, and adapted to growing in warm and humid conditions at an altitude of 1500 m above sea level. Ginger looks like a low shrub. It reaches a height of 90 cm. The plant forms several lateral shoots, which begin to dry out when the plant matures. Several stems grow from the rhizome. The leaves of the leafy stems are covered with a sheath that wraps around the stems at the base. The upper leaves on the stem have a long sheath, and the leaf plate is short, which is characteristic of this plant. The flowering stems are short, about 30 cm, and the sheath plate is covered with short leaves. The flowers are collected in a spike-shaped inflorescence at the end of the stem. The color of the flowers is purple-brown or yellow-brown. The stem is erect, rounded, hairless, surrounded by the sheath bases of two rows of lanceolate leaves, the leaf sheath is lanceolate or linear-lanceolate. The leaves are simple, dark green, arranged in a row on the stem. The base of the leaves is heart-shaped. The flowers are zygomorphic, the inflorescence is separate, consisting of a purple-brown or orange petal. The above-ground part is used as an additional raw material, the main raw material is the rhizome, harvested in autumn. After drying the rhizomes (50°C), they turn gray-yellow. The main components of the chemical composition of the ginger rhizome are essential oil and phenolic compounds - gingerols and shogaols, which provide its pharmacological activity.

Essential oil accounts for 1-4%. More than 100 components have been identified in ginger, the main part of which (50% of the total amount) is sesquiterpenes - α - and β -zingiberenes, curcumenes, β -sesquiphellandrene, β -bisabolene, α - and β -farnesenes, zingiberol, etc. Monoterpenes are found in smaller quantities, which give the rhizome its characteristic smell - geraniol (9%), linalool (1%), borneol, geranial, geranial acetate, isoborneol. The essential oil also contains aldehydes, alcohols, ketones and alkanes. The composition and amount of essential oil in ginger is significantly affected by the place of its cultivation or growth. The phenolic natural non-volatile substances that give the rhizome its bitter taste are gingerols (up to 8%). Their main type is 6-gingerol, with smaller amounts of 8-gingerol and 10-gingerol. The numbers in the names of gingerols indicate the products formed when they are hydrolyzed, for example, the hydrolysis product of 6-gingerol is hexanal, a six-carbon aldehyde. During drying and storage, gingerols can be partially converted to the corresponding

shogaols, which can then be converted to paradols, gingerdiones, gingerdiols and gingerdiol acetates. The combination of phenolic non-volatile compounds with essential oil components and other non-volatile substances (fatty acids) is called oleoresin. Its content is usually 3-11%, and sometimes it can reach 20%. Ginger rhizomes also contain amino acids, proteins, proteolytic enzymes, tannins, lipids (6-8%), sterols, fiber, vitamins, starch (up to 50%), mucilage, monosaccharides. Vitamins include ascorbic acid, niacin, thiamine, riboflavin, as well as small amounts of retinoids and tocopherols.

The purpose of the study: to study the anatomical structure of the medicinal ginger rhizome in order to identify specific diagnostic features for product identification.

Materials and Methods

To study the morphological and anatomical structure of the rhizome, it was fixed in 700% ethyl alcohol. The anatomical and histological structure of the rhizome was studied on the basis of transverse sections. The classification of the main tissues and cells is based on the classifications of S.F. Zakharevich (1954), K. Esau (1969), N.S. Kiseleva (1971). Anatomical and histological preparations were prepared by manual cutting, stained with methylene blue and mounted with a glycerin-gelatin mixture (Barykina, Veselova, Devyatov et al., 2004). Photomicrographs of the anatomical features of the leaf were taken with a Canon A123 digital camera using a computer microphotometer device using a BioBlue S/N – EC-2209333 microscope. Some images were processed on a computer using the Photoshop CS5 program.

Results and Discussion

During the study, the anatomical and histological structure of the medicinal ginger rhizome was comprehensively studied using microscopic methods. In the transverse section of the rhizome, its general shape was observed to be round or slightly oval. Structurally, the rhizome has a parenchymal-ligamentous structure, which is an anatomical feature typical of plants belonging to the class of monocots.

It was found that the outer part of the rhizome is covered with a number of oval or elongated rhizoderm cells. Rhizoderm cells are densely located and perform the function of protection from the external environment. Their cell walls are relatively thick and smooth, and in some cases, remnants of the cuticle were observed.

Under the rhizoderm is the primary cortical parenchyma, which consists of large, round or polygonal cells. The presence of well-developed intercellular spaces between the parenchyma cells was observed, which ensures the effective course of gas exchange processes.

The exoderm consists of 7–8 rows of cells, the cell walls of which were found to be significantly thickened. This structure of the exoderm indicates that it is adapted to ensure the mechanical stability of the rhizome and protect it from environmental influences.

The mesoderm part consists of large, isodimetric and oval parenchyma cells, in the cytoplasm of which numerous yellow essential oil droplets were observed. The presence of essential oil droplets is directly related to the pharmacological activity of this plant and is an important diagnostic sign providing its medicinal properties.

Numerous closed collateral-type conductive ligaments were observed to be scattered in an irregular manner between the mesoderm tissues. The vascular bundles are composed of xylem and phloem elements, which provide the transport of substances. The closed nature of the bundles indicates the absence of cambium tissue.

The endodermis consists of a series of cells surrounding the central cylinder, which are characterized by an elongated-oval shape and relatively thin walls. The endodermis acts as a physiological barrier that regulates the passage of substances into the central cylinder.

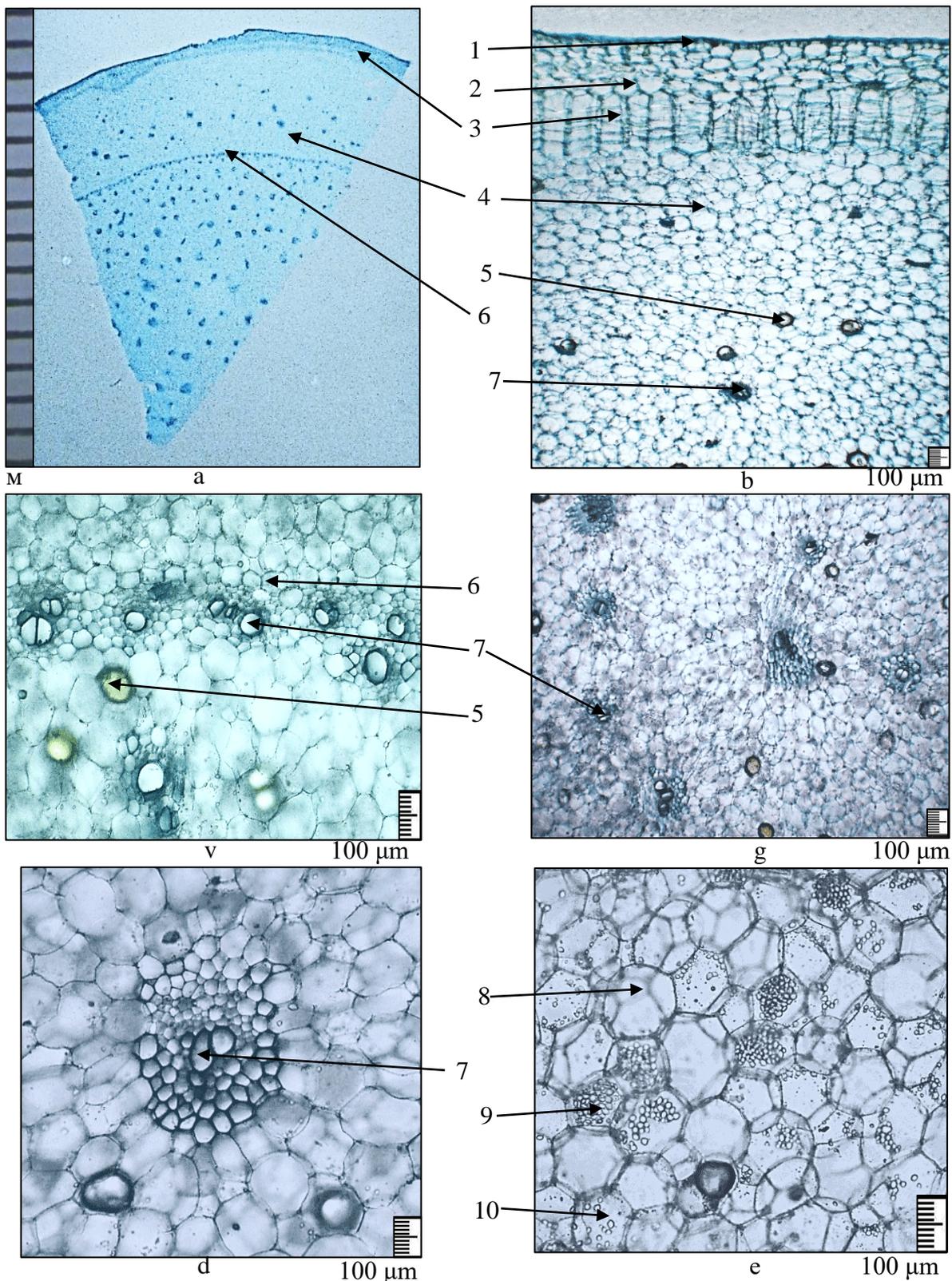


Figure 1. Anatomical and histological structure of a cross-section of the rhizome of *Zingiber officinale*: a – detail of the rhizome; b – rhizoderm, bark parenchyma and exoderm;

c, g – central cylinder and endoderm; d – closed collateral-type conducting ligament, e – parenchyma and hydrocytic cells; Legend: 1 – rhizoderm, 2 – bark parenchyma, 3 – exoderm cell, 4 – mesoderm, 5 – essential oil droplets,

6 – endoderm, 7 – closed collateral conducting ligament, 8 – parenchyma cells, 9 – starch granules, 10 – hydrocytic cells.

The central cylinder is well developed and consists mainly of large, thin-walled parenchyma cells. A large number of starch grains and essential oil droplets were observed in these cells. The abundance of starch grains confirms the function of the rhizome as an organ for accumulating reserve substances.

Hydrocytic cells were also detected among the parenchyma of the central cylinder. It was assumed that these cells may participate in water exchange processes. Also, the scattered arrangement of conducting bundles in the central cylinder is an anatomical feature characteristic of monocots.

As a result of the conducted studies, the presence of secretory cells rich in essential oils in the rhizome, the high accumulation of reserve substances, and the well-developed mechanical tissues indicated the high medicinal value of this plant.

Conclusion

In conclusion, the anatomical and histological structure of the rhizome of *Zingiber officinale*, grown in the climatic conditions of Uzbekistan, was comprehensively studied and important diagnostic features characteristic of the species were identified. In particular, the parenchyma-ligamentous structure of the rhizome, the significant thickening of the exoderm cell walls, the presence of large parenchyma cells in the mesoderm and central cylinder, the detection of essential oil droplets and starch grains in their composition, as well as the closed collateral arrangement of conductive ligaments are important anatomical features for this species.

These identified morphological and anatomical features are of great importance in standardizing medicinal plant raw materials, assessing their quality, and determining their species specificity. Also, the results of the study serve as a scientific basis for the correct identification of raw materials in pharmacognostic analyses, studying medicinal plant resources, and producing phytopreparations.

In addition, these results are also important for the comparative analysis of the anatomical features of the *Zingiber officinale* species with other species, the study of the patterns of accumulation of its pharmacologically active substances, and the scientific substantiation of the processes of introducing medicinal plants.

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